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Leakage Current on Porcelain and Silicone Insulators Under Sea or Light Industrial Pollution

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***Abstract*—The leakage current on heavily polluted silicone rubber insulators is usually smaller than on similarly polluted porcelain insulators. In this paper, results are presented that show that under light contamination, the currents on the two types of insulators can have similar values. Results are also presented from two different sites that show that under certain conditions the currents on silicone insulators can be higher than on porcelain. The phenomenon is explained, referring to the superior washability of the porcelain and moisture absorption of the pollution layer on the silicone rubber insulators during times of high humidity.**

***Index Terms*—Hydrophobicity, hygroscopic properties, pollution flashover, surface conductivity.**

I. Introduction

INSULATOR pollution research is usually performed in areas of medium to heavy pollution severity (e.g., close to the coastline). Results obtained at test stations and on lines in these environments indicate that under the same contamination (ESDD), the flashover voltages of hydrophobic insulators are higher and leakage currents are lower than on hydrophilic insulators. The performance of insulators under light contamination conditions has received less attention than that of insulators under heavy contamination. However, in many developed countries, due to increased awareness of the environment, especially a rapid decrease of industrial dust emission, many insulators are dimensioned for and operate under conditions of light pollution [1]. As the short stationary arcs that are associated with small leakage currents have been shown to be detrimental for the aging of silicone rubber insulators, there is a need to study the performance of insulators in these light pollution areas. In this paper, results from two diverse test stations are investigated which indicate that under light pollution conditions, higher leakage current pulses are obtained on hydrophobic insulators than on hydrophilic insulators.

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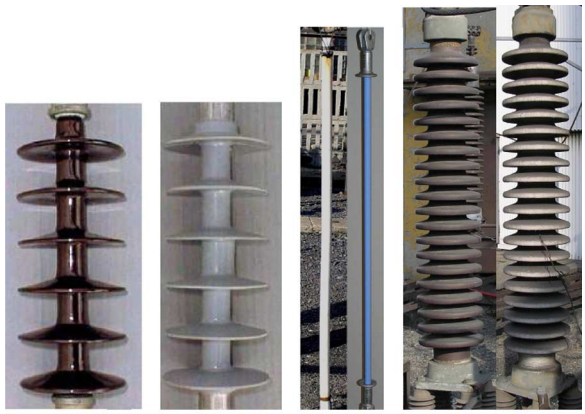

(a) (b) (c) (d) (e) (f)

Fig. 1. Insulators tested at the (a) and (b) Koeberg and (c)–(f) Glogow station.

II. Test Object and Experimental Procedure

Results obtained at the Koeberg Insulator Test Station (KIPTS), South Africa, and at the Glogow Test Station, Poland, were analyzed to compare the relative performance of hydrophobic and hydrophilic insulators under light pollution conditions. The Koeberg station is situated very close to the Atlantic shore, close to Cape Town in South Africa while the Glogow station is situated near a copper works, 400 km from the Baltic Sea in Poland.

At Koeberg, station tests were performed on insulators made of different materials but having the same profile, the same leakage distance of 61 cm, and a core diameter of 2.5 cm. This paper deals only with the porcelain [Fig. 1(a)] and the HTV silicone rubber insulators [Fig. 1(b)]. At Glogow, tests were performed on 105-cm-long cylindrical insulators made of porcelain [Fig. 1(c)], having a diameter of 3.0 cm, on silicone insulators, having a diameter of 2.5 cm [Fig. 1(d)], on porcelain posts SWZP with 20 sheds [Fig. 1(e)] and on porcelain posts with a silicone coating [Fig. 1(f)]. The leakage distance of post insulators was shortened by bridging a few shed divisions and leaving 10 or 14 sheds unbridged.

The daily highest leakage currents at Koeberg were measured by means of an online leakage current recorder (OLCA), while at Glogow, a LCM-1 monitor (from FGH Mannheim) was used. The test voltage at Koeberg was 12.7 kV (equivalent to 22 kV of phase—phase voltage) and at Glogow, it was 75 kV.

III. Results

As shown in Table I, during the summer (dry season), the leakage currents of the silicone insulators tested at Koeberg

TABLE I
10-MIN AVERAGE TIME-OF-DAY PEAK LEAKAGE CURRENTS AT 4:00, 12:00, AND 22:00, FOR WINTER AND SUMMER AT KOEBERG STATION

	Insulator	Maximum leakage current (mA)		
		Morning 4:00	Midday 12:00	Evening 22:00
Winter wet	SiR	10.9	2.8	12.1
	Porcelain	9.9	2.8	8.8
Summer dry	SiR	37	5.1	32
	Porcelain	54	3.9	41

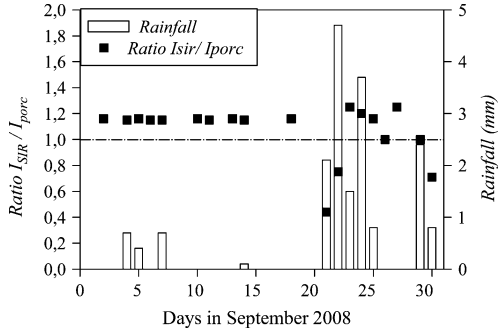

Fig. 2. Ratio of maximum daily currents on porcelain rods [Fig. 1(c)] to currents on silicone rods [Fig. 1(d)] for September 2008.

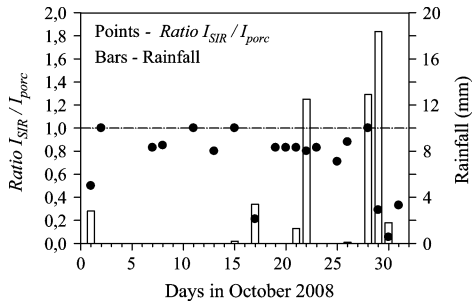

Fig. 3. Ratio of maximum daily currents on the porcelain post [Fig. 1(e)] to currents on the post with silicone coating [Fig. 1(f)] for October 2008.

station were generally less than those of the porcelain insulators. However, in the winter (wet season) the leakage currents of the silicone insulators were often 10% higher than those of porcelain insulators. The largest difference noted was on 3.08. 1999 when currents of 189 mA on silicone insulator and only of 119 mA on porcelain insulator were recorded [2]. The numbers of leakage current pulses recorded in the ranges 1–5, 5–20, and 20–100 mA were higher for the silicone insulators than on the porcelain insulators [2].

Typical leakage current results obtained at the Glogow test station are shown in Fig. 2 (for September 2008) and in Fig. 3 (for October 2008), together with the rainfall data. During these months, the relative humidity was generally above 80% and often above 90%. It will be noted that during the relatively dry first part of September, the leakage current of the silicone rubber-coated rods exceeded those of the porcelain rods, despite the fact that the diameter of porcelain rods is 3.0 cm and the diameter of silicone rods is 2.5 cm. As shown in the figure, during periods of rain, the currents on silicone insulators are usually smaller than on porcelain insulators [3].

The effect described before (ratio $I_{SIR}/I_{PORC} > 1$), does not occur every month as appears from the data shown in Fig. 3 for the porcelain and silicone-coated porcelain post insulators. Here, as normally expected, the current ratio I_{SIR}/I_{PORC} remains below 1.0 and sometimes attains values as low as 0.05. In a separate experiment on October 30, 2008, both post insulators were sprayed with water having a conductivity of 100 μS/cm and a voltage of 75 kV was applied, This resulted in a current of 145 mA on the porcelain post and only 2 mA on the silicone rubber-coated post insulator, a ratio I_{SIR}/I_{PORC} of 0.014).

IV. DISCUSSION

During rapid and intense but short-lasting wetting of insulators with excellent hydrophobic surfaces (as in the aforementioned experiment with artificial spraying), the currents on these insulators are many times smaller than currents on the hydrophilic insulators. Likewise, under natural conditions and longer periods of wetting, the currents on silicone insulators are less than the currents on porcelain insulators with the same profile.

However, under certain conditions, the currents on silicone insulators may exceed those on the porcelain insulators. This unexpected phenomenon may be explained by the fact that pollutants are more easily washed from the glazed porcelain surfaces than from the silicone rubber surfaces, which thus may accumulate more contaminants. The ESDD value on silicone insulators can therefore be 2 or 3 times higher than on porcelain insulators [2]–[4]. Therefore, at Koeberg, higher currents occurred on the silicone insulators during the rainy season when the porcelain insulators were cleaner than silicone ones. At Glogow, it rains almost the whole year, resulting in light pollution of the insulator surfaces, especially on the porcelain insulators. The silicone rubber insulators are, however, more polluted and absorb moisture during periods of high humidity [5]. Therefore, the currents on the silicone insulators can be slightly higher than the currents on porcelain insulators in very humid air but without rain.

V. CONCLUSION

Results presented from two different sites show that the currents on porcelain and silicone insulators can have similar values. Under certain conditions, the currents on silicone insulators can be higher than on porcelain. The phenomenon is explained, referring to the superior washability of the porcelain and moisture absorption of the pollution layer on the silicone rubber insulators during times of high humidity.

The persistent small leakage currents on the silicone rubber insulators may contribute to aging of the silicone rubber.

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